Vision Research 50 (2010) 1720–1727

Contents lists available at ScienceDirect

Vision Research

journal homepage: www.elsevier.com/locate/visres

How different types of scenes affect the Subjective Visual Vertical (SVV) and the Perceptual Upright (PU)

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ARTICLE INFO

Article history:
Received 6 October 2009
Received in revised form 17 May 2010

Keywords:
Subjective Visual Vertical
Perceptual Upright
Orientation perception
Scene perception
Object perception
Natural
Man-made

ABSTRACT

Different scenes contain varying cues to the direction of gravity. Do scenes with stronger cues differentially affect the ability of a scene to influence the direction of the Subjective Visual Vertical (SVV) and the Perceptual Upright (PU)? Using indoor, outdoor, natural and man-made scenes we asked participants to judge the orientation of pictures (Scene Upright: SU), viewed through a circular shroud, relative to the gravitationally defined upright. The standard deviation of these judgments was taken as an estimate of the reliability of the cues present in that scene. The SVV and PU were then measured against these scenes. The scenes in the SVV condition were tilted by ±22.5° and the SVV measured using a line. The scenes in the PU condition were tilted by ±112.5° and the PU was measure by a letter probe. The difference in orientation of the probes with the scene in these two orientations was defined as the visual effect. The man-made scenes affected the SVV more than the natural scenes. The visual effect was inversely proportional to the standard deviation with which the scene was judged as upright for the SVV but not PU. In order to be sure that the null result for the PU was not a ceiling effect we measured the SU and PU at brief exposure durations to increase the standard deviations of the SU. There was still no significant correlation between the standard deviations of the SU and the visual effect on the PU. This difference between PU and SVV suggests that the SVV may be more sensitive to global orientation information relevant to spatial orientation (as measured by Scene Upright) than the PU and that the more global spatial orientation a scene contains, the greater its effect will be on the SVV.

1. Introduction

Human perception is very sensitive to the orientation of stimuli. It is generally accepted that recognition of objects, letters, actions and people is faster and more accurate when they are perceived to be 'the right way up' (Jolicoeur, 1985; Maki, 1986; McMullen & Jolicoeur, 1992; Rock & Heimer, 1957; Rock, Schreiber, & Ro, 1994). Vision plays an important role in determining the perceived direction of upright. But how scenes vary in their ability to affect perception is not thoroughly understood.

The perceived direction of up has conventionally been assessed by the Subjective Visual Vertical (SVV): the direction at which participants set a line to the apparent vertical (e.g., Mittelstaedt, 1983). However, the SVV is not the only way to measure the perceived direction of up. As such, its direction does not always agree with the perceived directions of up derived from other measures. One of these measures is the Perceptual Upright (PU). The PU corresponds to the orientation at which objects are perceived to be the right way up and is measured using the Oriented CHAracter Recognition Test (OCHART). This task exploits the fact that the letters 'p' and 'd' rely on their orientation for their identity. The PU and SVV are both determined by a combination of visual and vestibular cues, together with an internal representation of the orientation of the body (Asch & Witkin, 1948a; Dyde, Jenkin, & Harris, 2006; Mittelstaedt, 1986, 1999). The SVV can be conceptualized as a direction that is more related to the orientation of the overall scene and as such is strongly influenced by the direction of gravity. The contribution of gravity to the SVV is almost ten times greater than that of visual cues or the body axis (Dyde et al., 2006). Thus, the SVV is almost entirely determined from vestibular cues. On the other hand, the PU is more related to the orientation of objects and perceptual recognition tasks and is more evenly influenced by the three main cues to orientation: vision, the internal representation of the body, and gravity (Dyde et al., 2006). In this study, we investigated the extent to which PU and SVV are affected by the orientation of different types of scenes.

While most scenes contain some orientation cues, different types of scenes may vary in the amounts and/or types of orientation cues that they provide to the viewer. For example, indoor and outdoor scenes differ with regards to their image statistics (Oliva & Schyns, 2000; Torralba & Oliva, 2003). Outdoor scenes can be further broken into man-made scenes and natural scenes

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doi:10.1016/j.visres.2010.05.027

and there is some computational evidence showing that image statistics can serve as the basis for classification along this dimension as well (Vailaya, Jain, & Zhang, 1998). Man-made scenes tend to include more vertical lines than do natural scenes (Switkes, Mayer, & Sloan, 1978) and the vanishing points in man-made scenes are more closely aligned with the vertical and horizontal whereas in natural scenes these angles appear more random (Kovač, Peer, & Solina, 2008). In other words, natural scenes contain fewer global orientation cues about the environment than man-made scenes. Thus, since they do not carry as much vertical information, natural scenes may be inherently more ambiguous than man-made scenes with regards to orientation cues and in turn may not influence the SVV or PU as much as man-made scenes.

In this study, we compared the effects of scene orientation on the SVV and PU for indoor, outdoor, natural and man-made scenes. We hypothesized that since man-made scenes contain more straight lines, the degree of certainty with which observers set scenes to upright would be higher for man-made scenes than for natural scenes. We also hypothesized that the certainty with which a given scene is set to upright would be predictive of the magnitude of the visual effect of that scene on both the PU and the SVV. Since most objects possess an axis of polarity that may be more local and less dependent on the global information about the scene, we hypothesized that the relationship between certainty of determining global scene orientation and the magnitude of the visual effect would be stronger for the measure of upright that captures spatial orientation (i.e., the Subjective Visual Vertical) as opposed to that which captures object orientation (i.e., the Perceptual Upright).

1.1. Convention

The orientations of all probe and background scenes are defined with respect to the body mid-line of the observer. 0° refers to the orientation of the body axis. Positive orientations are clockwise ('rightwards') relative to this reference orientation, negative orientations are counter-clockwise ('leftwards'), as seen by the observer.

2. Experiment 1

2.1. Introduction

The first experiment looks at how reliably the orientation of a scene is perceived and then assesses whether reliability can be used to predict the effect of the scene on the Perceptual Upright and the Subjective Visual Vertical.

2.2. Methods

2.2.1. Participants

Thirteen participants between the ages of 23 and 46 (four female and nine male) volunteered in this experiment. All participants were tested on the Scene Upright. Of the 13 participants, a group of eight was also tested in the SVV condition and a partially-overlapping group of eight was tested in the PU condition. Four participants were tested in all conditions. All observers had normal or corrected-to-normal vision. All observers gave their informed consent as required by the Ethics Guidelines of York University which complies with the Declaration of Helsinki.

2.2.2. Display

Stimuli were presented on a 13 in. Apple McBook laptop screen with a resolution of 48 pixels/cm. The screen was viewed at a distance of 25 cm through a black circular shroud that obscured peripheral vision and that reduced the viewing area to a circle subtending 28.5° of visual arc.

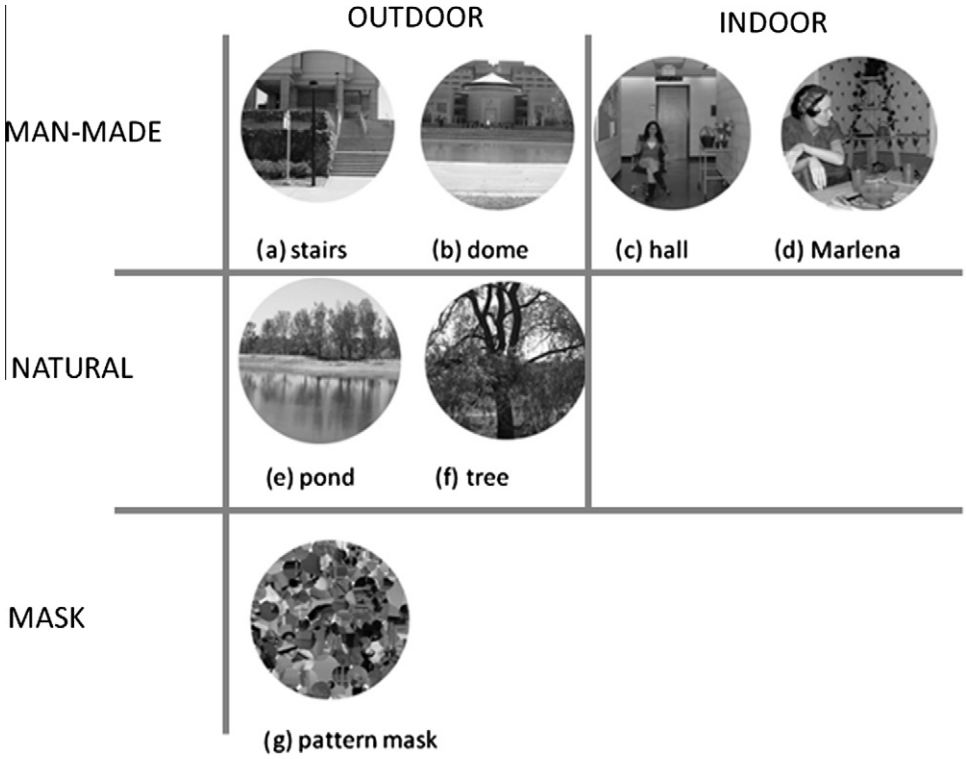

Fig. 1. The stimuli and mask used in this study. We refer to the scenes as (a) stairs, (b) dome, (c) hall, (d) Marlena, (e) pond and (f) tree throughout the text. We chose scenes that were outdoors (a, b, e, f), indoors (c and d), man-made (a–d) and natural (e and f). (g) The pattern mask used in Experiment 2 to limit the processing of the scene to the presentation duration. This mask was constructed by cropping circular bit segments of the scenes and overlaying them on top of each other.